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PREPARATION AND INVESTIGATION OF ABSORBING MAGNETOMETER CELLS WITH DOUBLE RADIOOPTICAL RESONANCE

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N67 18404 (ACCESSION NUMBER)
(THRU)
15 (PAGES)
1 (CODE)
CR-81874 (NASA CR OR TMX OR AD NUMBER)
06 (CATEGORY)
FACILITY FORM 602

GPO PRICE $

CFSTI PRICE(S) $

Hard copy (HC) 3.00

Microfiche (MF) .65

ff 653 July 65

14 DECEMBER 1966

PREPARATION AND INVESTIGATION OF ABSORBING MAGNETOMETER CELLS WITH DOUBLE RADIOOPTICAL RESONANCE

NOVINKI GEOFIZICHESKOGO PRIBIRISTROYENIYA
Magnitometriya, pp. 16-19, Vol. 23,
USSR, 1965.

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SUMMARY

Magnetometers utilizing the double radiooptical resonance phenomenon in vapors of alcaline metals and in metastable helium have been lately the object of greater and greater use as highly-sensitive and absolute devices, of which the absorbing cell is the principal part.

The present note describes the method worked out in the magnetic laboratory of IZMIRAN for their filling and covering for potassium, rubidium and caesium absorption chambers.

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* *

Lately, the magnetometers utilizing the phenomenon of double radiooptical resonance in alcaline metal vapors [1, 2, 3] and in metastable helium [4] were the object of the most widespread use as absolute and highly-sensitive devices.

The most important part of a magnetometer determining the line width and the signal intensity of magnetic resonance is the absorbing cell, that is, a glass chamber filled with vapors of the agent.

A method has been worked in the laboratory of IZMIRAN* for filling of and applying the covering to absorbing cells' inner surface for potassium, rubidium and caesium absorption chambers. The properties of alkylsilane covering of glass surfaces, assuring the maintenance of spin orientation during agent atoms' collisions with the walls of the cell, are described in literature [5, 6, 7]. As is shown by experiment, when utilizing long-chain type saturated hydrocarbons (such as tetracontane $C_{40}H_{82}$), the magnetic resonance signal is 1.5-2 times stronger than in the use of alkylsilane coverings. After 3 to 12 months of latter's use the chamber gives a signal 5 - 10 times smaller than originally.

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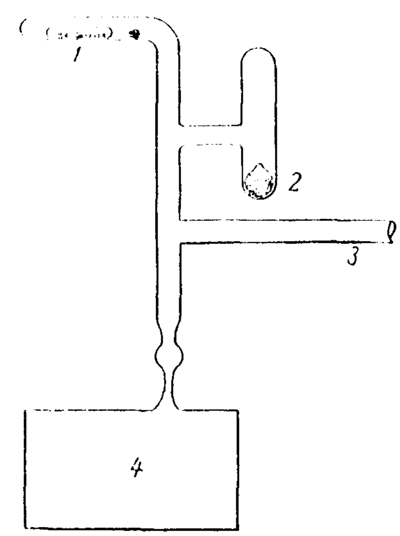
* Institute of Terrestrial Magnetism, of the Ionosphere and of Radiowave Propagation of the USSR Academy of Sciences

These results are in accord with the work [8]. The choice of the respective hydrocarbon is determined by the working temperature of the absorbing cell. For example, that of a cesium magnetometer is 20°C, and this is why all high-molecular paraffins, beginning from eicosane, are valid for the covering. In the rubidium magnetometer scheme we tested the high-molecular fractional mixtures of paraffins with a mean melting temperature from 60 to 114°C.

The sketch of Fig.1 shows how the absorbing cell is soldered to a vacuum installation. The absorption camera extension with intakes or drawn-out portions forming a reservoir (4) for the alcaline metal, is soldered to the vacuum system through the tube (3). A piece of paraffin, weighing a few milligrams is placed in one of the upper arms (1). An ampoule with alcaline metal or metal's salt pellet are introduced in the second arm with the respective reducing agent (for example, rubidium bichromate with zirconium or chloride of rubidium with potassium). The absorbing cell is subject to degassing during 4 hours at t = 420°C after it has been pumped out.



Sketch showing the absorption chamber's soldering to the vacuum system

After degassing the piece of paraffin is pushed into the chamber by an iron rod welded into the glass, which shifts by means of a magnet. Then, paraffin distillation is effected with the aid of slight heating, as a result of which it lies arbitrarily against the walls of the chamber. However, all the coatings thus obtained are not homogenous, because the various parts of the flask's surface are in different temperature conditions. The improvement in the quality of coating (covering) may be realized only after introduction into the chamber of the metal and its unsoldering from the vacuum system. It should be noted that during the distillation it is very important to see that the metal does not reach inside the chamber in the form of droplets, for this widens the magnetic resonance line. The chamber unsoldering is performed in a vacuum of $10^{-6} - 2 \cdot 10^{-7}$ torr. Immediately after unsoldering the chamber is placed into the operation scheme of the magnetometer with amplitude modulation of the radiopole in the frequency of 18 cps and its following basic characteristic are then investigated: signal-to-noise ratio (amplifier passband 2 cps) and the magnetic resonance line width. The checking of the quality of wall coating is performed directly with the help of an external sonde-solenoid, shifting along the chamber's surface is such a way that the direction of the weak sonde's radiofrequency field be perpendicular to the optical axis of the device. The sonde's displacement along several generatrices at simultaneous registration of signal intensity assures the detection of "gaps" in the coating. After verification the chamber is placed in a thermostat at temperature not exceeding the paraffin's melting point by some 20 – 30°C; it remains there during 10–12 hours, after which gradual lowering of temperature to room temperature level for 2 – 3 hours.

Analogous operations of paraffin sublimation and slow cooling are repeated several times, whereupon after each cycle the chamber is investigated by the described method in the magnetometer scheme.

Graphs of signal intensity and magnetic resonance line width measurements are plotted in Figures 2 and 3; they correspond to repeated sublimation operations for the two caesium chambers.

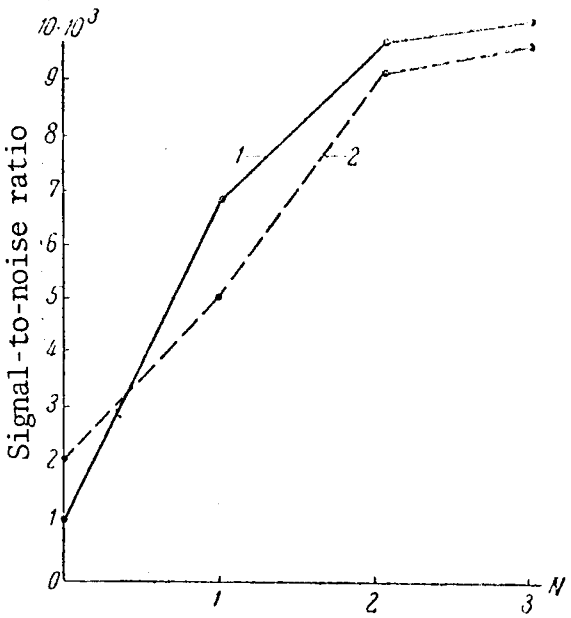


Fig.2. Signal-to ratio variation as a function of the number N of paraffin sublimations for two caesium chambers No.5 (1) and 14 (2)

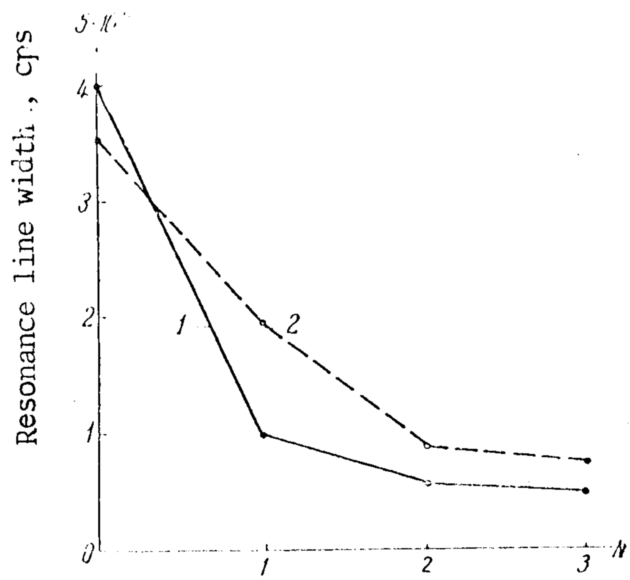


Fig.3. Resonance line width variation as a function of the number N of paraffin sublimations for the same two caesium chambers

As may be seen from the graphs, the improvement in the quality of the coating, linked with the disappearance of "gaps", is manifest in the increase of the signal-to-noise ratio and a decrease of the line width, whereupon the minimum value of the latter is determined by the inhomogeneity of the magnetic field within the volume of the investigated cell.

*** THE END ***

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